Joining global aerospace value networks: Lessons for industrial development policies

Governmental investments on the development of high-tech clusters are among the main policies for socioeconomic development, enabling countries to be part of global value networks. Our objective is to identify which are the strategies of countries that want to join global aerospace value networks, by means of an abductive case research. Countries were divided in three groups (A; B; C) according to their global aerospace exports share. The analytical framework used to identify the strategies has three dimensions: network structure, network governance and network dynamics. Results show different strategies according to the country's global exports share. While for countries at group A (exports above 1%) a strategy focused on the dimension network structure indicated a sustained high-tech sector, countries at group C tend to focus on specialization, taking advantage of shifts in technological paradigms to upgrade their development level. The dimension network governance is mainly related to governmental efforts towards the creation of clusters and associations, promoting specialization and collaborative work. Finally, the dimension network dynamics describes the attraction of foreign companies to qualify the clusters at countries who belong to group C, while countries at group A reinforce their R&D activities. The comparison between countries is helpful for governmental representatives who want to develop strategies towards increasing participation in an industrial global value network and for supply chain managers to help selecting the locations for their operations.

Keywords: Global Value Network, Aerospace Industry, Public Policy, Abductive Research

1. Introduction

The growing interconnection of industrial development and international trade has raised opportunities for companies of different countries. The success of global manufacturing activities, however, relies on the flexibility of the supply chain to respond to dynamic market changes [1]. Thus original equipment manufacturers (OEMs) are important business players on a global economy [2].

Global enterprises, such as those related to aerospace sector, rely on each country's policies – export regulation, local requirements, taxes and technology restrictions, among others – to manage its network of partners [3]. Considering the strong growth for commercial aircraft predicted until 2035 [4], the aerospace sector continues to rely on risk-sharing contracts and the OEMs' system integrator approach, thus, opening up opportunities for new entrants [5]. The potential for socioeconomic development, opportunities for skilled employment and increased economic value added reinforce the national strategic importance of the aerospace sector [6,7]. As OEMs face continued cost pressure, they increasingly outsource development and production of non-critical parts to lower cost partners [8], opening a wide range of opportunities for different countries.

Many countries, however, still face difficulties in developing their own aerospace capabilities to increase their share in global networks [9]. Due to the high entry costs and its inherent technological complexity, the aerospace sector is still considered a risky industry for both OEMs and suppliers. Current research based on the Aerospace supply chain focus on knowledge sharing and Innovation [10–12], risk management [13,14], and general characteristics of supply chain management [15–17]. It evidences this sector's movement to develop core competences in systems integration and supply chain development and co-ordination, leading to the emergence of new management solutions for product development [18]. Little attention, however, was given to the strategies that entrant countries face when they become part of international networks. In addition, due to the complexity of aerospace companies and clusters, we think that describing such networks as supply chains does not approach all the network of relationships necessary to develop such industrial cluster. For this reason, our analysis focus on global value networks. Consequently, the question "*what are the strategies for increasing participation of countries in global value networks?"* emerges as a gap of the current literature.

With this context in mind, this paper will address the development of aerospace value networks in different countries, suggesting that a country's position in the global value network can be classified according to its global exports share. Our objective is to identify which are the strategies for countries to increase their participation in the global aerospace value network. A framework of analysis, based on the dimensions of value network configuration [19,20], is used to identify strategies of countries with different levels of global exports share (according to exports data from the Observatory of Economic Complexity [21]).

This analysis is useful to improve a country's awareness about its current policies and the possibilities to maintain or upgrade its participation whilst, at the same time, meeting the needs of the major players of global aerospace value networks. Identifying the strategies related to countries with different global exports share may provide a benchmarking for those who want to be part of or to promote the development of a global value network. The identification of these strategies is also useful for supply chain managers to analyse different network configurations, identify attractiveness factors and prospects for growth in these regions.

The paper is organized as follows: section 2 reviews the literature with the objective of identifying the strategies of global value network configurations. Section 3 presents the research design for the analysis of countries with different global exports share: UK, Malaysia and Portugal. Section 4 presents the analysis of the participation in the aerospace industry of the three selected countries, while section 5 discusses the proposed conceptual framework of strategies for joining global value networks and section 6 presents the conclusions.

2. Literature Review

Supply and value chains, in general, describe linear flows of labour and production activities that companies perform to bring a product or service from its initial conceptualization to end use [22,23]. Value Networks is coined as an evolution of the "chain" analysis of partnerships, since networks properly indicate the diverse nature and extent of relationships between firms within the context of economic groups, while chains are more related to the vertical sequence of activities [24]. For this reason, it can be said that supply chain and value chains are part of the analysis of value networks.

Research on global value networks has revolved around issues related to their *configuration* – how organizations perform the activities across the Globe (the "structural elements") – and *coordination* – how activities are coordinated among partners (the "infrastructural processes") – [25,26]. This study is focused on the configuration dimension as an analytical prism to characterize the stage of aerospace industry development in different countries.

Novel configurations of value networks, at the country level, emerge from complex interactions between agents and their environment, which create distinct evolutionary paths [27]. The knowledge about the dimensions that characterize value network configurations may support policy makers in their initiatives aimed at increasing participation in global industrial networks.

This section is organized as follows. First, we present the context of the global aerospace value network as the setting for this research. Second, a conceptual framework is proposed for the characterization of the strategies of countries to increase their participation in the global aerospace industry. Finally, some insights about the different stages of development of countries in the global aerospace value network are presented.

2.1. Global aerospace value network

The aerospace manufacturing industry has experienced an extensive consolidation [7]. The large number of parts within each aircraft results in an equally large number of suppliers who rely on substantial capital investments, constant development of new products and access to specialized skills [28]. Due to the number of companies and parts, product development cycles for new aircrafts may take 15 years from an idea and design conception to the final product [29,30]. To extend product life cycle, the aerospace industry has adopted several business models in the last 50 years, including government-backed cooperation, build-to-print subcontracting, and risk-sharing partnerships [31].

In such dynamic environment, policies for the aerospace sector are focused on right-shoring – the restructure of global operations through a mix of offshoring, near-shoring and outsourcing – to achieve the best combination among costs, markets and resources [32]. Through the right-shoring analytical prism, countries with different industrial development levels may engage in aircraft development. While countries with developed aerospace sectors implement policies to retain and bring back high value added manufacturing, developing and emerging countries enact policies to attract and increase their share in the global aerospace sector.

The development of global aerospace value networks was pushed by the hesitation of private capital markets to finance the development of large civil aircrafts [5]. Pritchard and MacPherson [5] mention that this scenario led aircraft manufacturers towards global sourcing under risk-sharing partnerships and complex subsidy configurations, involving both domestic and foreign public agencies. The global sourcing approach is consistent with the move away from vertically integrated companies (with design, development, manufacturing, and assembly performed in-house), towards a supply network of many companies performing different functions [33]. These supply networks can be categorized into: OEM companies and its suppliers [2,18]; and service companies related to maintenance, repair and overhaul (MRO) activity [34,35].

Aircraft manufacturing activities (OEMs and suppliers) are known to be a catalyst for the creation of skilled jobs, leading to socioeconomic development, thus fostering different countries to invest in this field [36]. Ayeni *et al.* [34] highlighted the growing trend for OEMs to offer an array of support packages directly to the airline operators, thus incorporating MRO activities. Some of the services offered include complete packages for maintenance, servicing, and spare parts replacement over a fixed time period. The value network "expansion" strategy undertaken by suppliers of big aircraft producers – encompassing OEMs and MROs activities – has been a catalyst for various countries to position themselves as attractive destinations for hosting aerospace operations. As highlighted by Gereffi and Lee [37], it is important to understand the structure of value chains, as it may affect governmental policies for new entrants.

Therefore, to identify which strategies may be addressed by public policies, the relevant dimensions of value network configurations need to be identified. Even though the literature has provided numerous studies that aim at characterizing various regional aerospace sectors, along with their roles in global value networks [38–45], these characteristics are not clear. For this reason, a review about the dimensions of value network configurations in the global aerospace industry will be addressed in the next section.

2.2. Dimensions of value network configurations in the global aerospace industry

Being part of a global aerospace manufacturing network contributes for capability formation of local suppliers [46]. For this reason, a number of countries are developing strategies to increase their participation in the global aerospace value network. To increase the richness of the analysis, this study identifies the dimensions of value network configurations [19,20]. The proposed set of strategies represents an overview of the different development stages experienced by the aerospace value networks of selected countries. Based on these dimensions, a conceptual framework will be used to identify the strategies of countries in different stages of aerospace industrial development.

Supported by the identification of attributes from strategic management and network literature, Singh Srai and Gregory [20] proposed a definition of supply chain configuration. The definition comprises four dimensions of supply chain configuration:

- Network structure (e.g. tier structure and shape, composition, ownership),
- Flow of material and information between and within unit operations (e.g. value and non-value adding activities, process steps, levels of flexibility),
- Role, inter-relationships and governance between network partners (e.g. nature of transactions, complexity, governance, trust),
- "Value structure" of product or service (e.g. composition and product-structure, product replenishment modes, through life support services).

Using the lens of network analysis, Bellamy and Basole [19] captured the main structural and behavioural aspects of supply chain systems (SCS). They proposed an integrated framework that includes three dimensions:

- Structure - the structural properties and components of SCS,
- Dynamics - characterizes the behaviour of SCS and how they form, change and evolve,
- Policy and control - how firms in SCS formulate and employ their strategies.

These two perspectives - compiled by literature review and exploratory studies - were combined, thus resulting in the three dimensions of value network configurations used in this study: *network structure*, *network governance* and *network dynamics*. Even though the proposed structure is similar to the one developed by Bellamy and Basole

[19], their framework focus mainly on supply chain analysis, lacking a firm level analysis. This perspective was added by the article of Singh Srai and Gregory [20].

Afterwards, a review was also performed on regional studies about the aerospace industry to identify the respective sub-dimensions. The result is shown in Table 1, which presents the main dimensions with its sub-dimensions together with the related publications of the aerospace industry. These sub-dimensions constitute representative factors of an aerospace value network in a country. The remaining part of this section is dedicated to the description of these sub-dimensions.

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The dimension Network Structure consists of the agents that belong to the network, such as firms, suppliers, facilitators and costumers, among others, their relations and the principles that guide their development [19]. This dimension is divided into three sub-dimensions: composition, tier structure and location. The *composition* of the network refers to the typical profile (turnover, employment levels, etc.) of the companies that operate in the sector, and which can serve as attracting factors for a certain region [42,47]. *Tier structure* refers to the way these companies are locally structured along the value network, i.e. as suppliers of raw materials, systems integrators, assemblers, clients, R&D partners, etc. [7]. *Location* is related to the proximity and the dispersion of these companies (clustered or non-clustered in regions) and their influence in the collaboration modes between members [38] and on firm performance [36].

The second dimension - Network Governance - is limited here to the role of government and local associations. The concept of governance in the literature of supply chain management has been used to characterize the influence and actions of key organizations in the distribution of profit and risk in a global industry [37]. However, our approach focus mainly on governmental entities. The aerospace industry is extremely regulated, with high entry barriers, so the role of public entities has great relevance in the global aerospace industry. Therefore, this dimension is divided into two sub-dimensions: Government role and Local Associative Support. The *Government role* is related to regulations, incentives and in the general policy for the sector. Here government can be considered either national or supra national entities, and can have direct impact on networks' configuration. The second sub-dimension, *Local Associative Support*, is described by associations and other similar entities. They are the main responsible for fostering the development of local companies through training, financing and competitive intelligence planning activities [42].

The third dimension - Network Dynamics - addresses changes, circumstances and members' interactions that lead to a particular state/configuration/development stage of a network. It is divided into five sub-divisions: Historical Preconditions; Presence of Anchor Companies; Internationalization Processes; Local Demand Profile; Technological and Knowledge Capabilities. *Historical preconditions* describe how past events and starting conditions have helped in shaping the industry, such as the characteristics of early pioneers, the gradual introduction of management practices to improve design and production performances [48] and the entry mode in the global value network (e.g. through MRO, low cost manufacturing) [47]. The *presence of anchor companies* is also a critical issue for the attraction of specialized suppliers and creation of new companies [7]. The *internationalization processes*, either through a multinational corporation, foreign direct investment or other type of outside action, enables the transfer of external knowledge [42] and can grant access to foreign markets for local suppliers [48]. The sophistication of customers' requirements and a strong *local demand profile* creates pressures for achieving higher standards of quality, being mentioned as a relevant factor for assessing development stages of local aerospace value networks [36,42,49]. Finally, local *technological and knowledge capabilities* in terms of design, manufacturing and management along with the quality and availability of knowledge generation entities (universities, research institutions, etc.) are critical maturity aspects of a local aerospace network [41,44,48,50].

The aforementioned dimensions and sub dimensions serve as lens of analysis for the identification of the strategies of countries in different stages of aerospace industrial development. This research will be applied in three countries – United Kingdom, Malaysia and Portugal, selected due differences on the development stages of the aerospace industry.

3. Research design

The main objective of this article is to identify which are the strategies countries are developing to increase their participation in the global aerospace value network. To achieve this objective, a case study research was conducted [51] with countries that are willing to increase their participation in the global aerospace value network as the unit of analysis.

Case research can be used for theory generation, testing, and extension [51,52]. Inducting theory from case studies in the form of theoretical constructs or propositions is possible when the research process is based on collection and analysis of empirical evidence [53]. Theory testing through case research is, on the other hand, deductive in nature and aims at testing a general theory in a specific context by using triangulated data sources or longitudinal data [52,54]. However, this paper is underpinned by abductive research, i.e. it applies case research for theory extension [52,55,56]. Instead of focusing on generalizations, abductive research approaches particularities and specific situations, thus suggesting new theories in form of new hypotheses or propositions [56].

This research starts from the observation of a real-life phenomenon, namely, countries in distinct phases of aerospace industrial development. Prior theoretical knowledge is gathered through the literature of global value network configurations, for the purpose of identifying the strategies of value network configurations in the global aerospace industry (section 2.2). Then, countries in different stages of aerospace industrial development are analysed through the dimensions of value network configurations identified previously in the related literature, in a process described as "theory matching" by Spens and Kovács [56]. A theoretical extension is made in the form of a conceptual framework that is populated with the strategies of countries to promote their aerospace sector and increase participation in the global aerospace value networks.

Several strategies were applied to assure the quality of the case research [51]. Data was collected from secondary data sources, and by a detailed explanation of the data analysis (section 4). Internal validity was ensured by the observation of relevant theory related to the empirical context – countries in different shares of aerospace global exports – and external validity by developing a framework to characterize countries' strategy from the existing theory. Finally, reliability was achieved through the detailed explanation of the research process.

3.1. Case selection

The indicator most frequently used to assess country performance in global aircraft is exports [57]. In this study, countries' exports data were extracted from the Observatory of Economic Complexity [21] following the Harmonized system code rev. 2002 Harmonized System (HS) Classification - 88: Aircraft, spacecraft, and parts thereof, collected at the 6-digit level [58]. The Harmonized System is an international nomenclature for the classification of products. It allows participating countries to classify traded goods on a common basis for customs purposes, and it is internationally used for statistical analyses [59].

To approach an updated trend, the analysis of exports data focused on the post 2008 financial crisis. Global exports in general were affected by the 2008 financial crisis [60], and probably would add a bias to the performance of aerospace exports analysed here. As mentioned by Curran [60], global exports reduced in 2009 when compared to 2008, recovering its growth trend in 2010. In order to sole observe trends in countries' performance, i.e., without the influence of externalities and global economic downturns, this study analysed exports data from the period 2009-2016, which had a constant growth pattern.

For the analytical purposes, the study focused on countries with significant exports' share at the decimal point during the 2009-2016 period, which resulted in a sample of 45 countries. This list of countries along with respective exports' data is presented in Appendix A. To improve our analysis, reinforcing the differences between countries, the sample was divided into three groups. The first one (group A) represent countries with global aerospace exports share above 1%; the second group (group B) represent countries with global aerospace exports share above 0.2%; and a third group (group C) which represent countries with global aerospace exports share bellow 0.2%.

In the sample under analysis, countries in group A were responsible for approximately 90% of the global exports of aerospace products during the 2009-2016 period. Countries at group B (21 countries in the sample) had approximately 8% share of the global exports of aerospace products during the 2009-2016 periods. Finally, countries that belong to group C (11 countries in the sample), were responsible for approximately 1% share of the Global exports of aerospace products during the 2009-2016 periods.

In each of the three groups one country was selected for analysis. This procedure is appropriate in abductive research because it starts with an observed phenomenon [56]. The selection was based on prior data access by the researchers, including access to secondary sources that described the country's value network using the strategies described by our framework. Additionally, the selection was also based on the Compound Annual Growth Rate (CAGR) during the period under analysis, which should be positive to reflect the effect of the initiatives presented by these countries to increase their participation in the global aerospace value networks. As one of the top exporters, with a CAGR of 4.3% during the 2009-2016 period, the UK was chosen to represent group A, while Malaysia (CAGR of 5.5%), and Portugal (CAGR of 15.9%)

were selected to represent Group B and Group C, respectively. Figure 1 presents the exports for each of the selected country during the 2009-2016 periods.

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Figure 1. Exports of aerospace products from selected countries 2009-2016
Legend: United Kingdom (solid line), Malaysia (dashed line), Portugal (dotted line)
Source: [21]

It can be seen in figure 1, the exports value has a growing pattern along the years for all three countries. United Kingdom, the chosen representative of group A, has a superior volume when compared to the other countries, as presented on the left Y-axis. The values on the right Y-axis describes exports for Malaysia, representative of group B, and Portugal, representative of group C.

3.2. Data collection and analysis

Theory-extension case research uses abductive reasoning, an iterative process to match a general theory with an empirical context [52,55]. The sources of evidence used to characterize the configuration of value networks of the aerospace industry of the selected countries presented in section 4 were based on secondary data, namely government and industry reports, scientific literature and news and webpages, collected throughout 2014 and 2017. The process of data analysis consisted in searching the case data for evidence to characterize the configuration of industrial value networks of countries using the general theory identified in the literature (Table 1). This search towards matching theory and reality enabled a systematic identification of countries' strategies to increase their participation in an industrial value network. This extension to the theory of value network configuration will enable future theory building to identify relationships between countries' conditions and their participation in global value networks.

4. Analysis of country participation

In this section, we described the main characteristics of the aerospace sector in three countries. Firstly, we highlight the UK, representing countries with global exports share above 1% - Group A, followed by Malaysia, representing Group B (exports above 0.2%), and Portugal, representing Group C (exports bellow 0.2%). In the end, a comparison among the strategies of the three countries is listed in Table 2.

4.1. Group A: United Kingdom

The UK aerospace industry is the largest in Europe and second largest in the world behind the United States. The industry contributed £31.1 billion to the UK economy in 2015; of which £27 billion was exports earnings [61]. The UK aerospace industry cluster focuses on activities in the design, development, manufacture and support of aircraft, helicopters, missiles and space systems, such as satellites [39].

The strength of the UK civil aerospace sector is evident in its 17% global market share

[62]. As an industry leader, the UK civil aerospace value network is structured in a pyramid form with the chain broadening as it descends, encompassing more companies, and more skills and technologies [63]. These companies typically collaborate and compete across various aircraft development programs that are led by OEMs or lead companies. Lead companies are supported by a coordinated network of suppliers, who contribute to the manufacturing needs of components and parts that are often assembled as complete subsystems before being shipped for final assembly at OEMs' locations. Some of these subsystems are main aircraft components such as wings, engines, and landing gears; generating technological and knowledge capabilities in R&D, design, and engineering [62].

The tiered structure of the UK aerospace sector covers the whole value network, and ensures that companies are familiar with each other's capabilities, which supports close coordination in long development and manufacturing cycles. Employment figures obtained in the year 2013 indicate that these companies are scattered in various clusters around the UK, with concentrations in South West, East Midlands and the North West [64]. These clusters have benefited from proximity to other manufacturing activities such as automotive and steel manufacturing. The network was strengthened by joint industry-government efforts in the creation of AGP (Aerospace Growth Partnership) and ATI (Aerospace Technology Institute). These institutions are supported by a trade coalition of more than 3,000 companies across the UK [61]. Both trade and technology research efforts contribute to strengthening the development of required capabilities in the industry.

The UK aerospace industry players recognise that international competition will continue to intensify, especially from emerging challengers such as China, Russia, and India; whose combined demand for new aircrafts also happens to represent 15% of global demand in the year 2007 alone [65]. This is despite the known barriers to entry in terms of low manufacturing volumes and high requirements for design and product customisation relative to other industries. Even so, the UK aerospace industry has managed to improve on its productivity through continuous focus on supporting its value network.

The development of industry capabilities benefited from early beginnings in aircraft manufacturing during the Second World War, sparked by the patented invention of the turbojet engine by Sir Frank Whittle in 1930 [66]. This created a demand for technology and engineering skills, which led to collaborations with US companies in the 1940s. Today, the industry directly employs over 128,000 people and created more than 150,000 jobs in supporting industries [61].

4.2. Group B: Malaysia

Malaysia launched its first National Aerospace Blueprint in 1997, following a period of more than two decades developing the aerospace sector through defence offset programs [67]. The blueprint was aimed at setting a common direction for industry players and policy-makers to collaborate in establishing a strong aerospace sector that can help power economic growth. More importantly, the blueprint had set a target for Malaysia to be "a major aerospace player in the global scene by 2015" [67].

Pritchard and MacPherson [5] highlighted that OEMs had been moving away from build-to-print subcontracting relationships, to an internationally devolved design and engineering tasks for airframe development. With this arrangement, key components and sub-assemblies are designed and manufactured by external suppliers in emerging markets. The spillover activities from these, and the burgeoning passenger air travel market [34] particularly in Asia, provided the impetus needed by countries like Malaysia to develop capabilities in the aerospace manufacturing sector.

The activities for developing the Malaysian aerospace sector are structured along 7 pillars: 1st Tier investments; strategic domestic investments; engineering and design; research and technology; Aerotech parks; training; and military MRO [68]. These activities are conducted across the Klang Valley area, where the capital city of Kuala Lumpur and the government administrative city of Putrajaya are also located.

The creation of the Malaysian Aerospace Council (MAC) to steer the implementation of the first industry blueprint, combined with investment incentives and R&D grants offered through Malaysian Investment Development Authority (MIDA), have produced notable growth outcomes [69]. Most incentives and investments were focused on OEM's outsourced design and engineering services, build-to-print aero-structures and avionics components assembly, and commercial MRO, mainly in airframes and engines [68]. These capabilities are positioned at Tiers 3 and Tier 4 in the global aerospace value network structure.

The Malaysian government also set up AMIC (Aerostructure Manufacturing Innovation Centre) in 2012 to focus on R&D in aircraft structure manufacturing [70]. One of the key initiatives of Malaysia's recent economic transformation programme, "Asia Aerospace City" was announced in 2014 as a "complete business ecosystem for industry players in South East Asia" [71], which is also an effort to attract new investments.

In 2015, Malaysia launched a follow-up Aerospace Industry Blueprint to leverage on existing resources and infrastructure. The new blueprint identified a refreshed target for Malaysia to become "the number One aerospace nation in South-East Asia, and be an integral part of the global market by 2030" [69]. The implementation of the new blueprint focuses on seven core strategies including, developing new capabilities and enhancing industry competitiveness, and developing the required skillsets [68]. These strategic initiatives aim to support the development of aerospace competencies in Malaysia.

Malaysia's defence industrialization push in the 1970s was the catalyst to the capability development in the aerospace sector [72], leading to the creation of local companies such as Composite Technology Research Malaysia (CTRM), a first-tier supplier to BAE Systems, GKN and Vought Aerospace equipment and components. The Malaysian aerospace industry network dynamics have been further enhanced by the presence of OEMs such as Airbus and Augusta-Westland; as well as Tier 1 aerospace multinationals such as BAE Systems, GE and Honeywell [68]. These companies have created new requirements for local manufacturing capabilities and technical skills.

Malaysia has had various opportunities over the last forty years to establish itself within the global aerospace industry. Although its network dynamics may have gone through various false starts, today, Malaysia's technological and knowledge capabilities development is stabilizing. Currently, specific aerospace projects are being implemented, focusing on value network development and competency development through industry-led research and technology (R&T) initiatives [69].

4.3. Group C: Portugal

Portugal closely followed the inception of the aerospace industry, through MRO [73]. After a period of strong growth during the 1960s, driven by the Ministry of National Defence, the sector witnessed a sharp decrease in business volume with the end of the Colonial Wars. It was only in the 1980s, with the renewal of the military fleet, and the cooperation agreement signed with the European Space Agency (ESA) in 1996, that the sector experienced some resurgence. These factors point to a historic inability of the country to develop indigenous aerospace technological capabilities and its extreme dependence of external stimuli. Currently, MRO remains the most important segment, in terms of business volume. Manufacturing activity is dispersed in a fragmented value network composed of several small and medium enterprises (SMEs) in lower Tiers, delivering typically low value high volume parts.

The structure of value network is expected to change with the investments from Embraer in the installation of two manufacturing facilities in Portugal that supplies directly to the OEM in Brazil, and the acquisition of the largest MRO company of the country [43]. Embraer's strategy clearly demonstrates the intention of the OEM to gain greater access to European value networks' technological knowledge [74], through participation in European R&D project consortiums. The presence of Embraer is a landmark in Portugal, and is expected to attract new firms to the sector. However, the low volumes characteristic of this sector presents some challenges for most Portuguese firms, which are used to more volume intensive industrial sectors such as the automotive.

The governance of the value network, in terms of government and associations interventions, has directed efforts towards stimulating collaborative work, creation of new technology-based firms and training of the workforce [75]. These initiatives aim to complement and strengthen a fragmented value network. As an emerging sector, most suppliers are not exclusively dedicated to the aerospace industry and have a low level of specialization, delivering make-to-print parts. In addition, cooperation among local manufacturers has been promoted towards the sharing of resources and expertise that will hopefully deliver, in the future, high value added complex integrated systems. The presence of Embraer may create new dynamics for the sector and a novel governance structure that may improve local demand sophistication requirements.

As expected from a fragmented value network, R&D activity is concentrated in academia, with emerging ties with the industry. The development of the KC-390 aircraft involved a consortium of Portuguese R&D institutions led by Embraer, which potentiated the aerospace R&D productivity in the country. The strengthening of R&D activity in the country may benefit from the presence of the anchor tenant's R&D orientation and absorptive capacity in a particular technology [76]. In this regard, Portuguese companies have demonstrated technological capabilities in the development and manufacturing of metallic and composite structures [77], which can be converted to the specific requirements of the aerospace sector in order to increase its participation in the global value network.

Finally, table 2 presents a comparison of the characteristics of each country based on the value network configuration.

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5. Towards a conceptual framework for increasing participation

Each one of the analysed countries – UK, Malaysia, and Portugal – has distinct strategies according to their global aerospace exports share. Although the results of this study do not intend to be prescriptive, through recommendations of strategies they may offer some possible options for countries aiming at increasing their participation in the global aerospace value network. To observe the differences between countries, figure 2 presents a cross-country analysis of each country's strategy towards increasing their participation in the global aerospace value network.

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Figure 2 –Strategies to increase participation in global aerospace value networks

The findings show that, although some similarities among the strategies of each case country exist, each local value network is currently at its respective unique stage of implementation. The differences among groups arise from changes observed in business environments and the capability of companies and other organizations to address such changes, which creates a unique development path [27]. As a value network, public agents and organizations have its role on the development of each country's value network, and the collaboration among public policies and company's strategies may upgrade a certain country aerospace global exports share [26].

When analysing the dimension *Network Structure*, it was possible to observe that Portugal aerospace sector (which belong to group C) is characterized by a fragmented network of companies that manufacture non-complex parts of an aircraft. These networks are usually based on smaller-sized companies that, although possessing some technological capabilities, face difficulties to access global value networks. The strategies to increase participation includes the aggregation of key players, which specialize in delivering higher value added integrated systems or subassemblies. Specialization is critical since it allows an emerging sector to develop the resources and capabilities that are not easily found in global value networks. Shifts in technological paradigms also represent temporary windows of opportunity for countries at group C to leverage growth opportunities in new industries. On the other end, the main challenges observed in UK (representing countries at group A) are related to their ability to retain a wide aerospace value network range. Established companies continuously redesign their value networks in search for the right locations that enable them to reach optimum levels of performance and thus ensure competitive advantages and the sustainability of the local industry in the long term. In turn, the approach for Malaysia (representing countries at Group B) is to address higher value added parts and systems, with an emphasis in design instead of manufacture, when compared to the emerging stage. Countries at the group B should look at the accumulation of technological capabilities to position themselves in the global value network not only as manufacturing centres, but also as potential engineering services providers. The differences between countries with different global exports share reflects a value network maturity transition with significant contribution to different sections of Aerospace production process. At this stage, efforts are directed into strengthening technological capabilities and systems integration.

In terms of the dimension *network governance*, government support is a key factor at all groups of countries and an intrinsic feature of the aerospace global industry. Governmental institution support is more important at countries with lower exports shares, as it may function as a catalyst for business, providing directions for specialization and for collaborative work. The creation of clusters and associations are key to foster partnerships and complementary activities among companies in the same industry, strengthening the development of a competitive aerospace sector. At countries with higher exports shares, collaboration and specialization becomes less critical, since the industry has improved assets to self-organize.

In countries at groups B and C, the necessary *Network Dynamics* for the implementation of a new generation of suppliers and local capabilities is also connected to governmental initiatives to attract foreign large corporations. An industrial policy aimed at promoting the development of the aerospace sector in countries with lower exports shares can support the reconversion of technological capabilities from related sectors. As networks advance towards increasing country's exports participation, the dynamic may be focused on continuous R&D, thus ensuring that industry remains in the forefront of aerospace technologies. The risks involved in the lengthy development cycle of aerospace products are considerable, so it is natural to maintain a policy that includes R&D funding support from the government for local innovation to flourish.

6. Conclusions

Every global company evaluates operations location decisions on a regular basis. At the company level, decision makers have to assure the right shoring of their value network activities. At the country level though, decision makers have to create attractive conditions to improve local competitiveness and technological level of global value networks, which will ultimately influence the location decisions of companies. For this reason, this paper presents a study on the aerospace industry to characterize the strategies to increase participation of countries in global aerospace value networks.

Results show that at all network dimensions, top-down initiatives from governmental bodies have different impacts depending on the level of country's global exports share. Countries with lower exports shares perform the predominant role of an aggregator, stimulating collaborative work, it gradually shifts to a promotion role when implementing trade policies and attracting foreign investments. As described, companies of countries at groups C and B are in disadvantage when competing with companies at Group A. For this reason, the strategies are directed towards the development of supplier companies specialized in high-tech products, instead of trying to encompass a broad set of technologies. This may be supported by local governmental policies towards the attraction of international companies and the promotion of joint university-industry activities. For companies that belong to countries at Group A, these strategies are mainly geared towards continuous R&D to secure its leading position in the global value networks, developing both OEM and MRO activities.

The research methodology described in this study was based on an abductive method that identified the strategies of the three countries with different aerospace global exports share through secondary data collected from multiple sources. However, an analysis of the impacts of past aerospace development programs in each of the countries analysed was not considered in the study, which could have led to a richer overview of the contingencies of each country. A possible future research would be to refine this research through primary sources e.g., case studies in each of the countries based on semi-structured interviews with participants at different levels of the value network.

The main theoretical contribution of this article was addressed by the theoretical gap that guided the research question. The strategies of participation in global aerospace value networks, presented in a relational matrix of countries with different exports levels and three network dimensions, contribute to current research about value networks, supply chain management and aerospace OEM's and MRO's companies. Even though developed for the aerospace sector, the conceptual framework proposed in this research may be further applied at other value networks that hold similar characteristics. Consequently, the framework will be useful not only to analyse the strategies of several countries in one industrial sector, but also to analyse the strategy of one country in several industrial sectors. Hence, researchers may use the proposed framework to study the similarities and differences of the strategies for increasing participation in different industrial sectors.

The managerial contributions of this article are directed towards those agents who are interested in joining or supporting the development of global aerospace value networks. By providing an analysis of different groups of countries, local government may use our results as benchmarking to decide which are the necessary characteristics to support the creation of value networks, and which actions they could promote to join the global aerospace market. As observed, OEMs and suppliers are gradually incorporating MRO activities. As such, the development of new aerospace suppliers should also foresee MRO activities, gradually integrating maintenance services to their business model. Aerospace is a growing sector that, due to its high-tech profile, is a potential sector for socioeconomic development. Another managerial contribution is directed to supply chain managers that may use the proposed framework to analyse different local network configurations and then identify attractiveness factors for their operations in new countries and prospects for growth in regions they are already established.

------------------------------------- APPENDIX A HERE ----------------------------------

References

[1] J. Roh, H. Min, Implementation of a responsive supply chain strategy in global complexity: The case of manufacturing firms, Int. J. Prod. Econ. 147 (2014) 198–210. doi:10.1016/J.IJPE.2013.04.013.

[2] B.-W. Lin, Original equipment manufacturers (OEM) manufacturing strategy for network innovation agility: the case of Taiwanese manufacturing networks, Int. J. Prod. Res. 42 (2004) 943–957. doi:10.1080/00207540310001622449.

[3] R.C. Basole, W.B. Rouse, L.F. McGinnis, D.A. Bodner, W.C. Kessler, Models of complex enterprise networks, J. Enterp. Transform. 1 (2011) 208–230. doi:10.1080/19488289.2011.601397.

[4] T. Captain, A. Hussain, Global aerospace and defense sector outlook:Growth prospects remain upbeat, 2017. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/2017-global-ad-outlook-january.pdf (accessed November 17, 2017).

[5] D.J. Pritchard, A. MacPherson, Strategic destruction of the Western commercial aircraft sector: implications of systems integration and international risk-sharing business models, Aeronaut. J. 111 (2007) 327–334.

[6] P.K. Lawrence, D.L. Braddon, Strategic issues in European aerospace, Taylor & Francis Ltd, London, 2017.

[7] J. Niosi, M. Zhegu, Aerospace Clusters: Local or Global Knowledge Spillovers?, Ind. Innov. 12 (2005) 5–29. doi:10.1080/1366271042000339049.

[8] A. Gunasekaran, Z. Irani, K.-L. Choy, L. Filippi, T. Papadopoulos, Performance measures and metrics in outsourcing decisions: A review for research and applications, Int. J. Prod. Econ. 161 (2015) 153–166. doi:10.1016/J.IJPE.2014.12.021.

[9] F. Texier, Industrial Diversification and Innovation: an international study of the aerospace industry, Edward Elgar Publishing, Cheltenham, 2000.

[10] A. Corallo, R. Laubacher, A. Margherita, G. Turrisi, Enhancing product development through knowledge-based engineering (KBE), J. Manuf. Technol. Manag. 20 (2009) 1070–1083. doi:10.1108/17410380910997218.

[11] J. Mendonça, M. Heitor, The changing patterns of industrial production: How does it play for the Iberian Peninsula?, Technol. Forecast. Soc. Change. 113 (2016) 293–307. doi:10.1016/J.TECHFORE.2016.07.042.

[12] H.J. van Zuylen, K.M. Weber, Strategies for European innovation policy in the transport field, Technol. Forecast. Soc. Change. 69 (2002) 929–951. doi:10.1016/S0040-1625(02)00191-9.

[13] S. Farooq, C. O'Brien, Risk calculations in the manufacturing technology selection process, J. Manuf. Technol. Manag. 21 (2009) 28–49. doi:10.1108/17410381011011470.

[14] P. Figueiredo, G. Silveira, R. Sbragia, Risk Sharing Partnerships With Suppliers: The Case of EMBRAER, J. Technol. Manag. Innov. 3 (2008) 27–37. http://www.jotmi.org/index.php/GT/article/view/425 (accessed January 22, 2018).

[15] J.-T. Chiang, Defense conversion into a global system of proprietary technologies: The case of Taiwan's aircraft industry, Technol. Forecast. Soc. Change. 56 (1997) 77–85. doi:10.1016/S0040-1625(97)00003-6.

[16] R. Kumar BR, M.K. Sharma, A. Agarwal, An experimental investigation of lean management in aviation, J. Manuf. Technol. Manag. 26 (2015) 231–260. doi:10.1108/JMTM-12-2013-0174.

[17] R. Ruiz-Benitez, C. López, J.C. Real, Environmental benefits of lean, green and resilient supply chain management: The case of the aerospace sector, J. Clean. Prod. 167 (2017) 850–862. doi:10.1016/J.JCLEPRO.2017.07.201.

[18] R. Alfalla-Luque, C. Medina-Lopez, H. Schrage, A study of supply chain integration in the aeronautics sector, Prod. Plan. Control. 24 (2013) 769–784. doi:10.1080/09537287.2012.666868.

[19] M.A. Bellamy, R.C. Basole, Network analysis of supply chain systems: A systematic review and future research, Syst. Eng. 16 (2013) 235–249. doi:10.1002/sys.21238.

[20] J. Singh Srai, M. Gregory, A supply network configuration perspective on international supply chain development, Int. J. Oper. Prod. Manag. 28 (2008) 386–411. doi:10.1108/01443570810867178.

[21] MIT, Observatory of Economic Complexity, (2017). https://atlas.media.mit.edu/en/ (accessed November 17, 2017).

[22] G. Gereffi, K. Fernandez-Stark, Global Value Chain Analysis: A Primer, Duke CGGC (Center on Globalization, Governance & Competitiveness), 2016. https://dukespace.lib.duke.edu/dspace/handle/10161/12488 (accessed January 22, 2018).

[23] T.K. Hopkins, I. Wallerstein, Commodity chains: Construct and research, in: G. Gereffi, M. Korzeniewicz (Eds.), Commod. Chain. Glob. Capital., Greenwood Press, Westport, 1994: p. 334.

[24] S.A. Sherer, From supply-chain management to value network advocacy: implications for e-supply chains, Supply Chain Manag. An Int. J. 10 (2005) 77–83. doi:10.1108/13598540510589151.

[25] Y. Shi, M. Gregory, International manufacturing networks—to develop global competitive capabilities, J. Oper. Manag. 16 (1998) 195–214. doi:10.1016/S0272-6963(97)00038-7.

[26] H.W. Yeung, N. Coe, Toward a dynamic theory of global production networks, Econ. Geogr. 91 (2015) 29–58.

[27] T.Y. Choi, K.J. Dooley, M. Rungtusanatham, Supply networks and complex adaptive systems: control versus emergence, J. Oper. Manag. 19 (2001) 351–366. doi:10.1016/S0272-6963(00)00068-1.

[28] T. Williams, R. Maull, B. Ellis, Demand chain management theory: constraints and development from global aerospace supply webs, J. Oper. Manag. 20 (2002) 691–706. doi:10.1016/S0272-6963(02)00035-9.

[29] J.G. Francis, A.F. Pevzner, Airbus and Boeing: Strengths and limitations of strong states, Polit. Sci. Q. 121 (2006) 629–651. doi:10.1002/j.1538-165X.2006.tb00584.x.

[30] A. MacPherson, D. Pritchard, Boeing's Diffusion of Commercial Aircraft Technology to Japan: Surrendering the U.S. Industry for Foreign Financial Support, J. Labor Res. 28 (2007) 552–566. doi:10.1007/s12122-007-9005-2.

[31] C. Rose-Anderssen, J. Baldwin, K. Ridgway, P. Allen, L. Varga, M. Strathern, A cladistic classification of commercial aerospace supply chain evolution, J. Manuf. Technol. Manag. 20 (2009) 235–257. doi:10.1108/17410380910929646.

[32] W.L. Tate, L.M. Ellram, T. Schoenherr, K.J. Petersen, Global competitive conditions driving the manufacturing location decision, Bus. Horiz. 57 (2014) 381–390. doi:10.1016/J.BUSHOR.2013.12.010.

[33] F.M. Reed, K. Walsh, Enhancing technological capability through supplier development: a study of the UK aerospace industry, IEEE Trans. Eng. Manag. 49 (2002) 231–242. doi:10.1109/TEM.2002.803379.

[34] P. Ayeni, T. Baines, H. Lightfoot, P. Ball, State-of-the-art of "Lean" in the aviation maintenance, repair, and overhaul industry, Proc. Inst. Mech. Eng. Part

B J. Eng. Manuf. 225 (2011) 2108–2123. doi:10.1177/0954405411407122.

[35] M.C. Machado, M.A. Gomes Eller Araújo, L.M. Soto Urbina, F.R. Macau, A qualitative study of outsourced aeronautical maintenance: The case of Brazilian organizations, J. Air Transp. Manag. 55 (2016) 176–184. doi:10.1016/J.JAIRTRAMAN.2016.04.013.

[36] C. Beaudry, Entry, Growth and Patenting in Industrial Clusters: A Study of the Aerospace Industry in the UK, Int. J. Econ. Bus. 8 (2001) 405–436. doi:10.1080/13571510110079000.

[37] G. Gereffi, J. Lee, Why the World Suddenly Cares About Global Supply Chains, J. Supply Chain Manag. 48 (2012) 24–32. doi:10.1111/j.1745-493X.2012.03271.x.

[38] L. Biggiero, A. Sammarra, Does geographical proximity enhance knowledge exchange? The case of the aerospace industrial cluster of Centre Italy, Int. J. Technol. Transf. Commer. 9 (2010) 283–305. doi:10.1504/IJTTC.2010.035397.

[39] D. Braddorn, K. Hartley, The competitiveness of the UK aerospace industry., Appl. Econ. 3 (2007) 715–726. doi:10.1080/00036840500448391.

[40] N. Clifton, R. David, O. Ehret, D. Pickernell, An Analysis of Actual and Potential Clustering Structures, Stakeholder Governance Activities and Cross-locality Linkages in the Welsh Aerospace Industry, Eur. Plan. Stud. 19 (2011) 279–309. doi:10.1080/09654313.2011.532676.

[41] I. Dostaler, Competing in the global aerospace supply chain: The case of the Canadian aerospace industry, Oper. Manag. Res. 6 (2013) 32–43. doi:10.1007/s12063-013-0076-3.

[42] A. Elola, J.M. Valdaliso, S. López, The Competitive Position of the Basque Aeroespatial Cluster in Global Value Chains: A Historical Analysis, Eur. Plan. Stud. 21 (2013) 1029–1045. doi:10.1080/09654313.2013.733851.

[43] A. Goldstein, M.M. Godinho, The expansion of emerging economies' multinationals: the case of Embraer in Portugal, Int. J. Technol. Learn. Innov. Dev. 3 (2010) 226–244. doi:10.1504/IJTLID.2010.036492.

[44] S. Guillou, N. Lazaric, C. Longhi, S. Rochhia, The French defence industry in the knowledge management era: A historical overview and evidence from empirical data, Res. Policy. 38 (2009) 170–180. doi:10.1016/J.RESPOL.2008.10.015.

[45] J.H. Saleh, Will we see a regional or global duopoly in the satellite manufacturing industry? The European perspective, Space Policy. 21 (2005) 277–285. doi:10.1016/J.SPACEPOL.2005.08.006.

[46] D. Ernst, L. Kim, Global production networks, knowledge diffusion, and local capability formation, Res. Policy. 31 (2002) 1417–1429. doi:10.1016/S0048-7333(02)00072-0.

[47] J.M. Romero, Centripetal forces in aerospace clusters in Mexico, Innov. Dev. 1 (2011) 303–318. doi:10.1080/2157930X.2011.605872.

[48] D. Hickie, Knowledge and competitiveness in the aerospace industry: The cases of toulouse, seattle and north-west England, Eur. Plan. Stud. 14 (2006)

697–716. doi:10.1080/09654310500500254.

[49] G. Benzler, R. Wink, From agglomerations to technology- and knowledge-driven clusters: aeronautics cluster policies in Europe, Int. J. Technol. Manag. 50 (2010) 318–336. doi:10.1504/IJTM.2010.032679.

[50] P. Cooke, O. Ehret, Proximity and Procurement: A Study of Agglomeration in the Welsh Aerospace Industry, Eur. Plan. Stud. 17 (2009) 549–567. doi:10.1080/09654310802682115.

[51] C. Voss, N. Tsikriktsis, M. Frohlich, Case research in operations management, Int. J. Oper. Prod. Manag. 22 (2002) 195–219. doi:10.1108/01443570210414329.

[52] M. Ketokivi, T. Choi, Renaissance of case research as a scientific method, J. Oper. Manag. 32 (2014) 232–240. doi:10.1016/J.JOM.2014.03.004.

[53] K.M. Eisenhardt, Building Theories from Case Study Research, Acad. Manag. Rev. 14 (1989) 532–550. doi:10.2307/258557.

[54] M. Barratt, T.Y. Choi, M. Li, Qualitative case studies in operations management: Trends, research outcomes, and future research implications, J. Oper. Manag. 29 (2011) 329–342. doi:10.1016/J.JOM.2010.06.002.

[55] A. Dubois, L.-E. Gadde, Systematic combining: an abductive approach to case research, J. Bus. Res. 55 (2002) 553–560. doi:10.1016/S0148-2963(00)00195-8.

[56] K.M. Spens, G. Kovács, A content analysis of research approaches in logistics research, Int. J. Phys. Distrib. Logist. Manag. 36 (2006) 374–390. doi:10.1108/09600030610676259.

[57] D. Vértesy, The contours of the Global Commercial Aircraft Manufacturing Industry, in: S. Eriksson, H.-J. Steenhuis (Eds.), Glob. Commer. Aviat. Ind., Taylor & Francis Ltd, London, 2016: pp. 1–32.

[58] WCO, HS Nomenclature 2017 edition: Aircraft, spacecraft, and parts thereof, World Cust. Organ. (2017). http://www.wcoomd.org/-/media/wco/public/global/pdf/topics/nomenclature/instruments-and-tools/hs-nomeclature-2017/2017/1788_2017e.pdf?la=en.

[59] WCO, What is the Harmonized System (HS), (2017). http://www.wcoomd.org/en/topics/nomenclature/overview/what-is-the-harmonized-system.aspx (accessed November 12, 2017).

[60] L. Curran, The Impact of the Financial and Economic Crisis on World Trade and Trade Policy, Intereconomics. 44 (2009) 264–293. doi:10.1007/s10272-009-0305-z.

[61] Aerospace Growth Partnership (AGP), Means of Ascent The Aerospace Growth Partnership’s Industrial Strategy for UK Aerospace 2016, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/547122/agp-aerospace-strategy-2016.pdf.

[62] KPMG, The Future of Civil Aerospace, 2013. https://assets.kpmg.com/content/dam/kpmg/pdf/2013/06/the-future-of-civil-aerospace.pdf (accessed January 22, 2018).

[63] C.H. Fine, D.E. Whitney, Is the Make-Buy Decision Process a Core

Competence?, MIT Cent. Technol. Policy, Ind. Dev. (2002) 1–31. http://hdl.handle.net/1721.1/1626 (accessed January 22, 2018).

[64] P. Brien, C. Rhodes, The UK aerospace industry: statistics and policy, 2017. http://researchbriefings.files.parliament.uk/documents/SN00928/SN00928.pdf.

[65] C. Bédier, M. Vancauwenberghe, W. Van Sintern, McKinsey: The growing role of emerging markets in aerospace, McKinsey Q. (2008) 114–125+3.

[66] R. Schlaifer, Big business and small business: a case study, Harv. Bus. Rev. 28 (1950) 97–108.

[67] MIGHT, Malaysian Aerospace Strategy, (2007). http://www.might.org.my/Aironline/Publication/Open Forum LIMA 07/MIGHT.pdf.

[68] MIGHT, Malaysian Aerospace Blueprint 2030, (2015). http://www.might.org.my/en/Event Documents/Aero Bluetrint.MIGHT @ LIMA'15 Open Forum.pdf (accessed March 3, 2017).

[69] MITI, Malaysian Aerospace Industry Report 2016/2017, 2017. http://www.miti.gov.my/miti/resources/NAICO/MITI_Aerospace_Industry_Report_2016-2017.pdf.

[70] MIDA, Malaysia Investment Performance Report 2013, (2013). http://www.mida.gov.my/env3/uploads/PerformanceReport/2013/IPR2013 (accessed March 3, 2017).

[71] Bernama, Asia Aerospace City Construction To Start In 1Q 2016, Dly. Express. (2015). http://www.dailyexpress.com.my/news.cfm?NewsID=100679.

[72] R. Matthews, T. Yip, The Push and Pull of offset in the development of Malaysia's Defence and Security Technology Park, (2013). https://www.defencereviewasia.com/articles/203/The-Push-and-Pull-of-Offset-in-the-Development-of-Malaysia-s-Defence-and-Security-Technology-Park (accessed March 3, 2017).

[73] J.A.V. Ribeiro, A indústria aeroespacial em Portugal: contributos para um novo modelo económico, Instituto Superior de Economia e Gestão, 2001. http://hdl.handle.net/10400.5/641.

[74] A.C. Reis, The Aerospace Industry: a Descriptive and Prospective Empirical Analysis for Portugal, 2011. https://fenix.tecnico.ulisboa.pt/downloadFile/395143242118/Resumo_AR.pdf (accessed January 22, 2018).

[75] República, Resolução do Conselho de Ministros n.o 78/2010, Lisbon Presidência Do Cons. Minist. (2010). https://dre.tretas.org/dre/279622/.

[76] A. Agrawal, I. Cockburn, The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems, Int. J. Ind. Organ. 21 (2003) 1227–1253. doi:10.1016/S0167-7187(03)00081-X.

[77] R.E. dos S. Caetano, Produção aeronáutica: análise do desenvolvimento nacional, Universidade da Beira Interior, 2012. http://hdl.handle.net/10400.6/2009 (accessed November 17, 2017).

[78] D. Smith, G. Ibrahim, Cluster Dynamics: Corporate Strategy, Industry Evolution and Technology Trajectories – A Case Study of the East Midlands

Aerospace Cluster, Local Econ. 21 (2006) 362–377. doi:10.1080/02690940600952004.

[79] A.E. Lublinski, Does Geographic Proximity Matter? Evidence from Clustered and Non-clustered Aeronautic Firms in Germany, Reg. Stud. 37 (2003) 453–467. doi:10.1080/0034340032000089031.

[80] J. Niosi, M. Zhegu, Anchor tenants and regional innovation systems: the aircraft industry, Int. J. Technol. Manag. 50 (2010) 263–284. doi:10.1504/IJTM.2010.032676.

Table 1 - Summary of prior knowledge about the dimensions of global value networks configuration

Dimension	Sub-dimension	References
Network structure	Composition	[36,39,42,47]
	Tier structure	[7,78]
	Location	[7,36,38,47,48]
Network governance	Government role	[7,39,42,44,47–49]
	Local associative support	[40,42,79]
Network dynamics	Historical preconditions	[36,42,44,48]
	Presence of anchor companies	[42,47,48,80]
	Internationalization processes	[7,39,42]
	Local demand profile	[49,79]
	Technological and knowledge capabilities	[36,41,42,44,47,49,50]

Table 2 - Comparison of the value network configuration (structure, governance and dynamics) of selected countries

Dimension	Sub dimension	United Kingdom	Malaysia	Portugal
Network structure	Composition	• £31 billion revenue in 2016. • 280,000 jobs in 2016; • 3,000 firms.	• Revenue of £2.5 billion in 2016. • 21,200 jobs in 2016; • 200 firms in 2016.	• Turnover of EUR 1.7 billion in 2016. • 18,500 jobs in 2016. • 70 companies, mostly SMEs subcontractors.
	Tier structure	• Presence of all supply chain tiers, from Primes to Tier 4. • Six Primes in design and assembly operations, 10 to 20 Tier 1 companies in assembly and/or manufacture of sub-sections, 100 to 200 Tier 2 companies involved in manufacture of sub-sections and more than 800 Tier 3 and 4 companies producing machined components and sub-assemblies, or specialized in the production of particular components.	• OEM's outsourced design and engineering services. • Build-to-print aerostructures and avionics components assembly. • Commercial MRO (mainly) in airframes and engines.	• Majority positioned in lower Tiers (raw materials, tools, equipment and make-to-print suppliers). • Existence of two Tier 1 suppliers, established through FDI in the country.
	Location	• Some clustering in regions, mainly South West, East Midlands and North West.	• Some clustering in Peninsular Malaysia, mainly in Klang Valley.	• Emerging cluster in Southern region, driven by Embraer. • Mould & Die cluster in Central region supplying the aerospace sector.

Dimension	Sub dimension	United Kingdom	Malaysia	Portugal
Network governance	Government role	• Formation of Aerospace Growth Partnership (AGP) in 2011, a joint industry-government effort. • Creation of Aerospace Technology Institute (ATI) in 2013, representing joint industry-government funding for investment in technologies. • R&D tax benefits.	• Malaysian Aerospace Council as steering body to guide industry-government collaboration in implementing the National Aerospace Blueprint since 1997. • Formation of NAICO (National Aerospace Industry Coordinating Office) in August 2015 to implement initiatives identified in the blueprint. • Investment incentives and R&D grants through MIDA.	• Discontinued support due to cyclical financial crises.
	Local associative support	• UK Aerospace, Defence, Security and Space (ADS) a trade organisation representing 3,000 companies across UK aerospace supply chain. • National Aerospace Technology Exploitation Programme (NATEP) that focus on mid-Technology Readiness Level capabilities through collaborative support	• Aerostructure Manufacturing Innovation Centre (AMIC) to carry out R&D relating to aircraft structure manufacturing and also serves as a high-level study and training centre. • Asia Aerospace City (AAC) initiative that offers a complete business ecosystem for industry players in South East Asia.	• Three associations have formed the AED Portugal to explore sinergies and support the Aeronautic, Defense and Space Industry. • Two “on the job training” facilities created near the two Tier 1 established in the country (one in 2010 and the other in 2012) have formed already more than 800 professionals.

Dimension	Sub dimension	United Kingdom	Malaysia	Portugal
		in the lower tiers of the UK Civil Aerospace supply chain.		
Network dynamics	Historical preconditions	• Turbojet engine was invented by British-born Sir Frank Whittle in 1930, sparking a collaboration with GE in the USA in 1942.	• Industry began with establishment of MRO operations in 1970s, as part of defence procurement offset programmes.	• Entry through MRO in the inception of the aeronautic industry in 1918. • Period of expansion in the mid 20th century followed by contraction due to loss of captive markets.
	Presence of anchor companies	• Airbus, Bombardier, Augusta-Westland.	• OEMs – Airbus, Augusta-Westland; Tier 1 – BAE Systems, GE, Honeywell, Rolls-Royce.	• Embraer Portugal, supplier of the parent company in Brasil, installed in 2012 two manufacturing facilities. Which resulted in a turnover inflection from 38,5 million € in 2012 to 88,8 million € in 2014. • Presence of French Tier 1 companies: Lauak and Mecachrome.
	Internationalization processes	• Multinational corporations, foreign direct investments.	• Multinational corporations, foreign direct investment, offset programmes.	• MRO services to aircrafts of major OEMS. • Foreign direct investments to Tier 1 production facitilites.
	Local demand profile	• Local component and parts manufacturers in various aircraft platform	• Manufacturing of aircraft composite parts for Airbus and Boeing airplane models	• Driven by requirements of MRO and Defence.

Dimension	Sub dimension	United Kingdom	Malaysia	Portugal
		development, especially for wings, engine and landing gear.	such as the A320, A350, B737 and B787.	
	Technological and knowledge capabilities	• R&D, design and engineering capabilities.	• Component and parts manufacturing, maintenance, repair and overhaul (MRO) activities, design and development and the assembly and operation of light aircrafts and support services. • UniKL's (University of Kuala Lumpur) Malaysian Institute of Aviation Technology (MIAT) wholly-owned by the government.	• Nine research institutions with joint projects with the industry.
References		[4,6,33,36,39,61-66]	[34,43,46,67-72]	[6,43,73-77]

Appendix I

Ranking	Countries	Exports value 2009-2016 (In millions of dollars)	Global exports share 2009-2016
Group A			
1	United States of America	444385,75	25,5%
2	France	416731,99	23,9%
3	Germany	299673,35	17,2%
4	United Kingdom	102596,57	5,9%
5	Canada	90091,46	5,2%
6	Italy	37758,57	2,2%
7	Brazil	37685,99	2,2%
8	Japan	35424,83	2,0%
9	Spain	32610,78	1,9%
10	India	18603,81	1,1%
11	Singapore	18570,78	1,1%
Group B			
12	China	16871,73	1,0%
13	Switzerland	16797,02	1,0%
14	Israel	12778,53	0,7%
15	Russia	11259,95	0,6%
16	Ireland	11159,67	0,6%
17	Netherlands	10628,42	0,6%
18	South Korea	10474,29	0,6%
19	Belgium-Luxembourg	9157,30	0,5%
20	Austria	8596,24	0,5%
21	Mexico	8125,79	0,5%
22	Australia	7572,76	0,4%
23	Malaysia	6331,09	0,4%
24	Poland	5818,62	0,3%
25	Sweden	5642,46	0,3%
26	Argentina	4945,12	0,3%
27	Czech Republic	4306,69	0,2%
28	Turkey	4271,00	0,2%
29	United Arab Emirates	3787,21	0,2%
30	Saudi Arabia	3343,05	0,2%
31	Thailand	2798,19	0,2%
32	Denmark	2789,97	0,2%
33	South Africa	2735,12	0,2%
34	Hong Kong	2627,81	0,2%
Group C			
35	Norway	2532,13	0,1%
36	Ukraine	2462,88	0,1%
37	Finland	2243,59	0,1%
38	Morocco	2026,71	0,1%
39	Philippines	1907,49	0,1%
40	Portugal	1760,29	0,1%
41	Greece	1501,13	0,1%
42	Tunisia	1449,72	0,1%
43	Indonesia	1327,30	0,1%
44	Romania	1300,86	0,1%
45	Kazakhstan	966,61	0,1%

Source: Observatory of Economic Complexity [21] following the Harmonized system code rev. 2002 Harmonized System (HS) Classification - 88: Aircraft, spacecraft, and parts thereof.